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(54) Title of the Invention: PASTE FOR ADHESION USE

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PATENT SPECIFICATION

1. Title of the Invention: Paste for Adhesion Use

2. Claims:

(1) An adhesive paste for attaching a semiconductor chip to a metal substrate in the formation of a semiconductor package, main components of said paste comprising first fillers, which are insulators of a spherical shape and of a predetermined dimension, and second fillers which are particles of a smaller diameter than said predetermined dimension of said first fillers and which have a high coefficient of thermal conductivity, both said fillers being combined and kneaded with a binder resin and a solvent.

(2) The paste of Claim 1, wherein the diameter of said first filers is within the range of 50 µm to 300 µm.

3. Detailed Description of the Invention

(Summary)

The invention relates to an adhesive paste for use in the manufacture of semiconductor chips and intended for stabilization of strength in adhesive connections. The main components of the adhesive paste of the invention comprise first fillers in the form of spherical insulating bodies having a diameter within the range of 50 µm to 300 µm and second fillers which have particles smaller in diameter than the first fillers. Both fillers are mixed and kneaded with a binder resin and a solvent.

(Field of the Invention)

The present invention relates to an adhesive paste used in the manufacture of semiconductor packages composed of metal substrates and semiconductor chips attached to the substrates.

In the past, it was a general practice to attach semiconductor chips to ceramic substrates or packages with the use of eutectic alloys, such as, e.g., Au-Sn. However, in order to improve characteristics of the circuits, it would be advantageous to isolate the semiconductor chip from the electric potential of the package substrate.

In particular, it is especially important to isolate chips from the substrate for diminishing noise generated from the potential of the substrate, when the chip operates on high frequencies. In such cases, attachment is accomplished with the use of epoxy or polyamide resin pastes.

(Description of the Prior Art)

Fig. 3 is a cross section of a semiconductor package for use in a device operating on high frequencies. In this device, a semiconductor chip 1 is isolated from a substrate 2.

The package of the aforementioned device has a construction described below. More specifically, the substrate 2 comprises a composite material in the form of a sintered body of tungsten (W) or molybdenum (Mo) with inclusion of copper (Cu). In order to attach the semiconductor chip 1, the substrate is coated with a layer 3 of a ceramic, such as Al_2O_3. Furthermore, the substrate 2 also supports a ceramic frame 4, and the fabrication of a pattern is completed by connecting the semiconductor chip 1 with lead wires 5.

The surface of the frame 4 is metallized, and after the installation of the semiconductor chip 1 is completed, a cover 6 is soldered with the use of metal,

such as Kovar [cobalt-nickel-iron alloy –TR. NOTE]. As a result, an impedance-matched hermetically-sealed structure is formed.

In the construction described above, the semiconductor chip 1 is attached to the ceramic layer 3 with the use of a solder or a resin paste having an epoxy or polyamide resin as a main component.

If in the attachment of the chip 1 with the use of a resin paste the adhesive layer 7 is too thin, deformations (stress) may develop because of a difference in coefficients of thermal expansion between the semiconductor chip 1 and the ceramic layer 3. If these deformations are not absorbed, cracks occur in the adhesive layer 7 and weaken the adhesion strength of the connection.

If, on the other hand, the adhesive layer 7 is too thick, the stress is readily absorbed, but the semiconductor chip 1 acquires an unstable position and is connected with an unstable adhesive force.

In the above case, the adhesive layer 7 can be maintained at a uniform thickness either by compression after adhesion, or by building the thickness up to a predetermined level after a temporary compression. Alternatively, the frame can be placed into a special tooling for making the thickness not thinner than the predetermined rated value. The problem associated with such a method is that it does not allow control of the adhesive layer thickness.

Furthermore, connection through the ceramic layer increases the thickness of the package.

(Problems Solved by the Present Invention)

As has been shown above, the semiconductor chip is adhesively attached to the package by a resin paste and through a ceramic layer placed onto the substrate. However, in order to ensure stability of the adhesive connection, the thickness of the adhesive layer should be constant.

(Means for the Solution of the Problem)

The above problem is solved by utilizing a paste of the invention for adhesion use in attaching a semiconductor chip to a metal substrate for the formation of a semiconductor package. Main components of the paste comprise first fillers, which are insulators of a spherical shape with a diameter ranging from 50 µm to 300 µm, and second fillers which are particles of a smaller diameter than the diameter of the first fillers . Both fillers are combined and kneaded with a binder resin and a solvent.

(Action)

In the method of the invention, the thickness of the adhesive layer is maintained constant by adding first fillers of a spherical shape having a diameter equal to the thickness of the layer to the material of the adhesive layer. In order to improve removal of heat from the semiconductor chip, it is recommended that these fillers have high thermal conductivity.

Furthermore, the first spherical fillers 9 that have a diameter equal to the thickness of the adhesive layer are combined with second fillers 10 which are mixed with a conventional adhesive paste and have excellent thermal conductivity matched with the conductivity of the first fillers.

Fig. 1 is a schematic view that shows the structure of the paste of the invention. It can be seen that the adhesive layer 7, which is located between the substrate 2 and the semiconductor chip 1, contains the first fillers 9 that determine the thickness of the adhesive layer 7, the second fillers that remove the heat generated by the semiconductor chip 1, and a binder resin 11 that works as an adhesive agent 11.

The first fillers 9 can be manufactured from glass and plastic and have to satisfy the following requirements:

(1) they should comprise spherical bodies of a constant diameter and should be made from an insulating material;
(2) in order to provide a stable adhesion force, they should have diameters within the range of 50 μm to 300 μm.

The second fillers 10 can be made from aluminum nitride (AlN), boron nitride (BN), diamond powder, etc., and have to satisfy the following requirements:

(1) they should comprise an insulating powder of high thermal conductivity;
(2) for effective removal of heat, the powder particles should be in good mutual contact;
(3) the particles should have dimensions from 2 μm to 5 μm.

The binder may be represented by an epoxy resin, polyamide resin, or another conventional heat-resistant resin used as an adhesive agent.

The amount of the first fillers 9 added to the paste depends on the width of the gap between the substrate 2 and the semiconductor chip 1 and should be small enough to prevent inclination of the semiconductor chip 1. Results of the experiments showed that the amount of the first fillers would sufficient if after spreading the paste over the fillers 9 to the level of thickness equal to the diameter of the first fillers 9, the surface area occupied by the first fillers exceeds 5% but does not exceed 30%.

In order to provide excellent thermal conductivity, the second fillers 10 should have tight mutual contact between the particles, and if they are represented by such a material as BN of a low specific gravity (2.34), they can be added in an amount of about 40 wt.%. If, however, the second fillers 10 are made from a material of high specific gravity, the content of the second fillers can be increased and in the case of a metal powder may reach the maximum value of 85 wt.%.

Fig. 2 is a sectional view of a package produced with the use of the adhesive paste of the invention. Since the adhesive layer 7 is formed directly on the substrate, removal of heat is improved, and the thickness of the adhesive layer 7 is maintained constant due to the use of the first fillers 9.

The size of the first fillers 9 depends on the dimensions of the semiconductor chip 1, but in general should be within the range of 50 μm to 300 μm.

(Practical Example)

The paste was prepared with the use of the first fillers in the form of silica (SiO_2) glass particles having 100 μm diameter and of the second fillers in the form of AlN (specific gravity 3.05) having an average particle diameter of 10 μm. More specifically, the adhesive paste was prepared by kneading the following components in a three-roll mill:

SiO_2 glass (1st filler)	6 parts by weight
AlN (second filler)	44 parts by weight
Polyamide precursor (binder resin)	20 parts by weight
N-methylpyrrolidone (solvent)	30 parts by weight.

The obtained paste was spread in the chip-location position over a substrate that comprised a composite material produced from W and Cu. After attachment of a semiconductor chip with application of pressure, the unit was heated to 250°C. The N-methylpyrrolidone that had a boiling point of 202°C was evaporated, the unit was heated for 30 min. at 300°C, and the adhesive paste was cross-linked and polymerized.

The obtained adhesive layer had a thickness of 100 μm, and the position of the semiconductor chip was stable.

[Effects of the Invention]

As compared to a conventional adhesive paste, the paste prepared by the method of the invention provides stable position of semiconductor chips and improves adhesive strength of the connection.

The adhesive past used in the practical example may find application in adhesive connections that provide electrical isolation of the connected parts.

However, if the connection should be conductive, the AlN, Bn, and diamond grains may be replaced with a metal powder, such as Ag, Au, or the like. In this case, the parts will be connected through a conductive layer of a uniform thickness.

4. Brief Description of the drawings

Fig. 1 is a schematic sectional view of an adhesive paste layer of the invention.

Fig. 2 is a cross-sectional view of a package prepared with the use of the adhesive paste of the invention.

Fig. 3 is a sectional view of a known semiconductor package.

In the drawings:

1	semiconductor chip	2	substrate
3	ceramic layer	6	cover
7	adhesive layer	9	first fillers
10	second fillers	11	binder resin

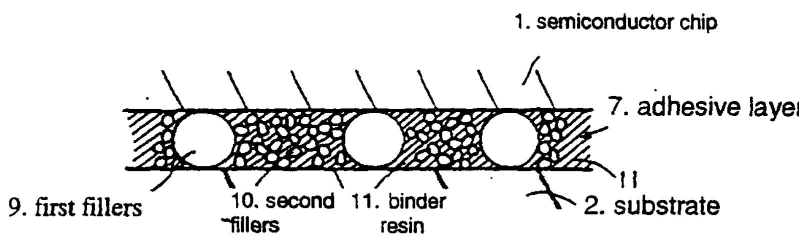

FIG.1

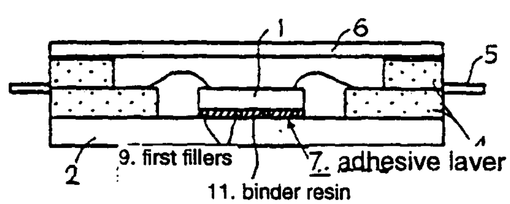

FIG.2

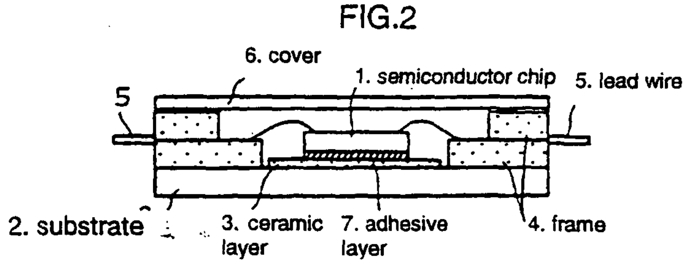

FIG.3